

ZOOLOGY.—*Three new species of coccidia from the Canada goose, Branta canadensis (Linné, 1758).* MARION M. FARR, U. S. Bureau of Animal Industry. (Communicated by E. W. Price.)

For several years the Zoological Division of the Bureau of Animal Industry and the Disease Section of the U. S. Fish and Wildlife Service have been cooperating in a study to determine the cause or causes of mortality among Canada geese overwintering at Pea Island National Wildlife Refuge, which is located in North Carolina. During this investigation three species of coccidia, apparently not heretofore described, were recovered. The descriptions of these species, as well as notes on the life cycle of one of the species, are given in this paper.

Critcher (1950) reported *Eimeria truncata* (Railliet and Lucet, 1891) from the Canada goose on Pea Island National Wildlife Refuge and suggested that this parasite might be a factor in mortality among Canada geese there. Levine (1951) described *Eimeria magnalabia* from *Branta canadensis interior* on Horseshoe Lake Game Refuge, Illinois. In 1952, he gave a brief description of another new species, *Eimeria brantae*,¹ from the lesser Canada goose, *Branta canadensis leucopareia*.

***Eimeria hermani*, n.sp. Figs. 1, 2**

Sporulated oocyst.—17.5 to 19.5 μ by 24.3 to 27.6 μ ; most frequently 18.9 by 25.6 μ . Shape index (width divided by length) 0.64 to 0.76; most frequently 0.71. Shape ovoid, slightly flattened at one end. Micropyle prominent, 3.2 μ in diameter, located at narrower flattened pole of oocyst. Oocyst wall colorless, thick, smooth; composed of two layers which are not easily distinguished unless wall is broken as shown in Fig. 2. Outer layer 0.95 μ thick, slightly thinner at micropyle; inner layer 0.4 μ thick, expanding around micropyle into irregular lobes which hang down into oocyst. A dark line of refraction is visible within wall of sporulated oocyst, particularly at end opposite micropyle; this may represent an inner membrane, although none was seen when wall was broken. No oocystic residual body and no polar body seen. Sporocysts 7.6 to 9.4 μ by 13.5 to 14.1 μ ; each slightly pointed at

ends, with thin wall, an inconspicuous Stieda body, and finely granular sporocystic residuum dispersed around sporozoites. Each sporozoite elongated, rounded at one end and pointed at the other, and doubled over within sporocyst. Nucleus of sporozoite almost centrally located, being a little nearer rounded posterior end. A large ellipsoidal refractile body fills rounded end of sporozoite and a smaller spherical, refractile body is just anterior to nucleus. Under favorable conditions (e.g., when slide is gently warmed) sporozoites move about vigorously within sporocyst. Sporulation is completed within 48 hours at room temperature.

Prepatent period.—Five days.

Hosts.—*Branta canadensis* (type host); *Anser anser* (experimental host).

Location.—Throughout small intestine.

Localities.—Pea Island National Wildlife Refuge, North Carolina (type locality); Seney National Wildlife Refuge, Michigan.

This species is named in honor of Dr. Carlton M. Herman, U. S. Fish and Wildlife Service.

Table 1 is a chart of the species of *Eimeria* reported from ducks and geese. Reference to this chart shows that *E. hermani* is readily differentiated from all other species, except, perhaps, *E. brantae* Levine, 1952. However, the oocysts of *E. hermani* are in general larger than those of *E. brantae*.² Since the description of *E. brantae* is too inadequate for identification, the present species is considered as new.

***Eimeria striata*, n.sp. Fig. 3**

Sporulated oocyst.—13.7 to 18 μ by 18.9 to 23.6 μ ; majority varying between 15.5 to 17.5 μ by 20.2 to 22.9 μ . Shape index 0.65 to 0.86, majority 0.72 to 0.78. Shape elliptical to ovoid; micropyle prominent, 2.7 μ in diameter. Oocyst wall thick, composed of two layers; outer layer pale yellow, finely striated and pitted, about 0.95 μ thick, slightly thinner at micropyle; inner layer smooth, colorless, about 0.4 μ thick, expanding slightly at micropyle. One or more refractile polar granules present but no oocystic residuum observed. Sporocysts 7 to 8 μ by 10 to 12 μ , each with a small Stieda body at one end; the other

¹ After this paper was submitted, a description and figure of the unsporulated oocyst of *E. brantae* from the feces of *Branta c. parvipes* were published: LEVINE, N. D. A review of the coccidia from the avian orders Galliformes, Anseriformes and Charadriiformes, with descriptions of three new species. Amer. Mid. Nat. 49: 696-719. 1953.

² At the micropyle the oocyst wall of *E. hermani* is slightly flattened, and the inner layer of the wall is expanded into irregular lobes, while *E. brantae* is not flattened and the expanded portion of the inner wall is apparently smooth.

end rounded or slightly pointed; coarsely granular sporocystic residuum present. Sporozoites elongated and doubled over within sporocyst, at least 2 refractile bodies within each sporozoite. Sporulation completed within 72 hours at room temperature. However, polar bodies do not usually appear until a day or two after sporulation has been completed.

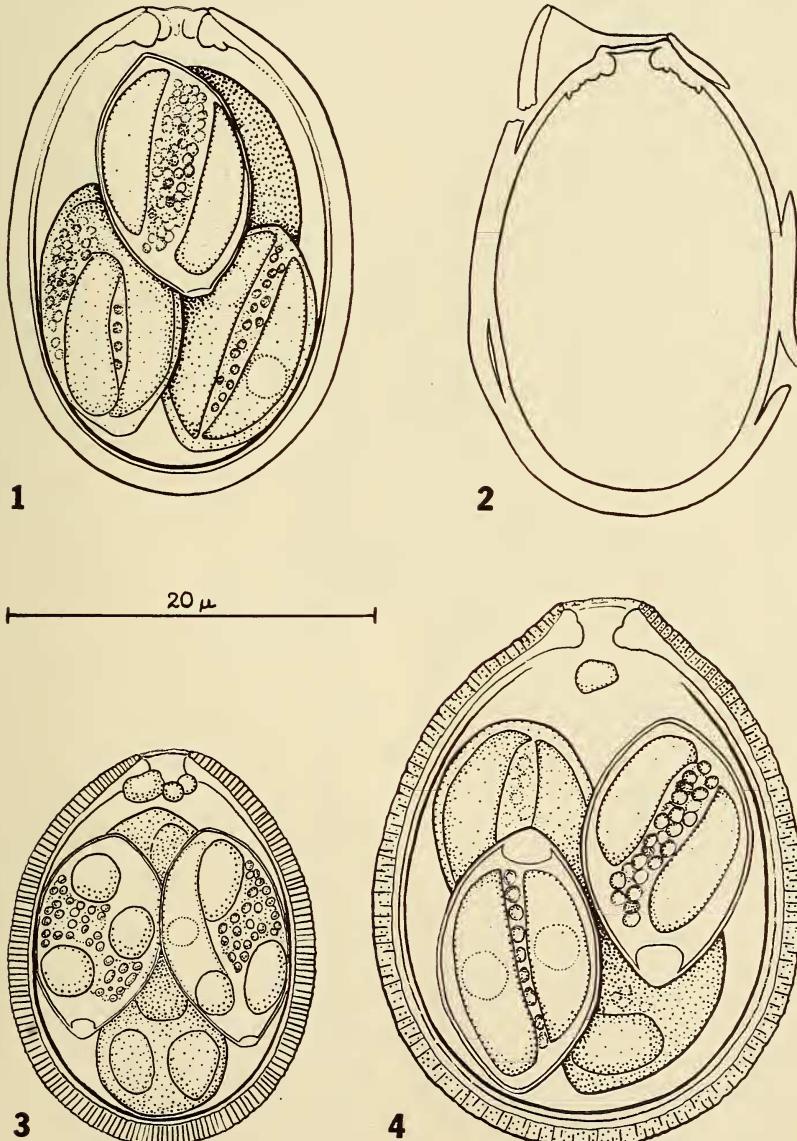
Prepatent period.—A few oocysts on fifth day, major shower on sixth day.

Hosts.—*Branta canadensis* (type host); *Anser anser* (experimental host).

Location.—Small intestine.

Localities.—Pea Island National Wildlife Refuge, North Carolina (type locality); Seney National Wildlife Refuge, Michigan.

Eimeria striata most closely resembles *Eimeria magnalabia* Levine, 1951. However, the oocyst of *E. striata* has one or more polar bodies, each sporocyst has a small Stieda body, the pale yellow outer layer of the oocyst wall becomes thinner around the micropyle and the colorless inner layer becomes thicker around the micropyle. On the other hand the *E. magnalabia* oocyst has neither polar bodies nor Stieda bodies, the brown-



FIGS. 1-4.—1, *Eimeria hermani*, n. sp., sporulated oocyst; 2, *Eimeria hermani*, n. sp., broken oocyst showing the two layers of the wall; 3, *Eimeria striata*, n. sp., sporulated oocyst; 4, *Eimeria fulva*, n. sp., sporulated oocyst.

TABLE I.—CHARACTERS DIFFERENTIATING OCYSTS OF SPECIES OF EIMERIA REPORTED FROM DUCKS AND GEESE

Species	Host	Location	Size	Shape	Wall	Microyle	Residual body	Polar body	Sporulation time	Prepatent period
<i>E. anseris</i> , Kotlan (1932) emend. Kotlan, 1933	Domestic goose	Small intestine, mainly posterior portion	13-18 μ X 16-23 μ	Pear-shaped	Colorless	Present, promi- nent	In oocyst and sporocyst	1 to 2 days	7 days	
<i>E. brantae</i> , Levine, 1952	<i>Branla cana- densis leuco- parea</i>	Unknown	18 X 21 μ	Ovoid	Colorless	Present				
<i>E. bucephala</i> , Christiansen and Maelsen (1948)	<i>Somateria mollissima</i>	Entire small intestine	13-20 μ X 25-39 μ	Ovoid or el- lipsoidal; one side may be indented	Light brown; very finely sculptured	Present, rather narrow	In sporocyst only	Few po- lar in- clusions	4 days	
<i>E. fulva</i> , n. sp.	<i>Branla cana- densis, Anser anser*</i>	Small intestine	20.2-25.2 μ X 25.6-32.4 μ	Broadly ovoid, sometimes al- most pyriform, slightly flat- tened at mi- croyle	Brown outer layer, striaed and pitted; colorless smooth inner layer with lobes at microyle	Present, large	In sporocyst only	Usually present	3 to 4 days	9 days
<i>E. hermani</i> , n. sp.	<i>Branla cana- densis, Anser anser*</i>	Small intestine	17.5-19.5 μ X 24.3-27.6 μ	Ovoid, slightly flattened at mi- croyle	Colorless, smooth, 2 layers inner layer enlarged at micro- yle	Present, large	In sporocyst only	Absent	2 days	5 days
<i>E. magnalabia</i> , Levine, 1951	<i>Branla cana- densis interior</i>	Feces	15.1-17.3 μ X 21.7-24 μ	Slightly ovoid	Brownish yellow pitted, enlarged into lobes at micro- yle, colorless in- ner layer?	Present, large	In sporocyst only	Absent		
<i>E. novensis</i> , Kotlan, 1933	Domestic goose	Small intestine, pos- terior por- tion	17-21 μ X 25-33 μ	Pear-shaped, truncated an- terior pole	Brown, thick	Present, large				
<i>E. parvula</i> , Kotlan, 1933	Domestic goose	Small intestine, pos- terior por- tion mainly	10-14 μ X 10-15 μ	Round or el- liptical	Colorless, delicate	Absent				5 days

<i>E. striata</i> , n. sp. <i>Branta canadensis, Anser anser</i> *	Small intestine	13.7-18 μ X 18.9-23.6 μ	Elliptical or ovoid	Pale yellow, outer layer pitted and striated; colorless smooth inner layer thickened at micropyle	Present, large	3 days	5 to 6 days
	Kidney, uriniferous tubules	11.7-21.6 μ X 14.3-27 μ	Ovoid, truncated	Colorless, smooth, delicate	Present, large	1 to 3 days	5 to 6 days
<i>E. truncata</i> , (Railliet and Lucet, 1891)	Domestic goose, <i>Branta c. canadensis</i> , duck			Occasionally in oocyst, always in sporocyst			

* Experimental

ish-yellow outer layer of the oocyst wall is expanded into thick lobes around the micropyle, and the colorless inner layer was visible only at the end opposite the micropyle.

***Eimeria fulva*, n.sp.**

Fig. 4

Sporulated oocyst.—20.2 to 25.2 μ by 25.6 to 32.4 μ ; most frequently 21.6 by 29.7 μ . Shape index 0.64 to 0.85, majority varying between 0.71 and 0.77. Shape usually broadly ovoid, occasionally almost pyriform, slightly flattened at narrower pole. Micropyle prominent, 3.3 to 4 μ in diameter, located at narrower pole. Oocyst wall 2-layered; outer layer pitted and transversely striated, brownish yellow in color, 1 μ thick and slightly thinner at micropyle; inner layer smooth and colorless, 0.6 μ thick and expanding into a rather smooth ridge around micropyle. A dark line of refraction is present within inner surface of oocyst wall, especially evident at end opposite micropyle; this may represent an inner membrane. A large refractile polar granule is usually present at narrower pole of sporulated oocyst. Sporocysts 8.3 to 9.7 μ by 13.5 to 14.8 μ , pointed at both ends, each sporocyst with a prominent Stieda body. A coarsely granular sporocystic residuum partially obscures elongated sporozoites which are doubled over within sporocyst. Sporulation completed within 72 to 96 hours at room temperature.

Developmental stages.—Experimental infections in both domestic and Canada geese showed grossly that the parasite occurred throughout the small intestine. A thickening and congestion of the intestinal wall and an accumulation of greenish mucus accompanied severe infection. The time required for the completion of the life cycle was nine days.

Studies of tissue fixed on the last four days of the life cycle showed that the developmental stages were most abundant in the anterior portion of the small intestine. About 144 hours after inoculation, numbers of small schizonts, each measuring about 13 by 15 μ and containing 16 to 30 small merozoites, were observed within the epithelial cells of the tips and sides of the villi. About 169 hours after inoculation, numbers of small schizonts were still present in the epithelium and numbers of immature gametocytes, which occurred singly, or in groups of 2, 3, 4, and 5, were found within the epithelium of the tips and sides of the villi; some were also seen in the tunica propria and in the necks and fundi of the

intestinal glands. In cases where the host cell was not completely destroyed the cytoplasm was stretched in a thin line around the parasite and there was no hypertrophy of the nucleus. However, in many cases the host cell was destroyed, consequently, some of the gametocytes had moved to the basement membrane and others had penetrated into the tunica propria. Often there was a clear space between the parasite and the host tissue. At 193 hours after inoculation, masses of developing gametocytes and numbers of nearly mature macrogametocytes and microgametocytes were present. Microgametocytes measured between 29 to 37.7μ by 34.8 to 46.4μ and the more mature ones appeared to be multicentric. The more mature macrogametocytes varied from 20.3 to 23.7μ by 26 to 30.4μ . At 217 hours after inoculation, masses of gametocytes were seen along the basement membrane and numbers of oocysts were present.

Prepatent period.—Nine days.

Hosts.—*Branta canadensis* (type host), *Anser anser* (experimental host).

Location.—Throughout small intestine.

Localities.—Pea Island National Wildlife Refuge, North Carolina (type locality); Seneca Falls, N. Y.; Seney National Wildlife Refuge, Michigan.

Type specimens.—U. S. N. M. Helm. Coll. no. 47605.

This species is unlike any of the coccidia described from geese and ducks except *E. nocens*

Kotlan, 1933. *E. fulva* differs from *E. nocens* in that the outer wall of the oocyst of *E. fulva* is pitted and transversely striated; and a large polar body is usually present in the sporulated oocyst and the parasite occurs throughout the small intestine. Kotlan (1933) did not mention the shape of the sporocysts of *E. nocens* nor did he state whether a Stieda body was present.

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